Assessment of Indoor Particulate Pollution in a Lecture Hall Complex

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ASSESSMENT OF INDOOR PARTICULATE POLLUTION IN A LECTURE HALL COMPLEX

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ABSTRACT

Air quality inside learning environment of schools and colleges is vital for students' health and their academic performance. This study aims to assess the particulate pollution in Lecture hall complex of a technical institute situated at Roorkee city in north India. Coarse, fine and submicron particles (PM_{10}, $PM_{2.5}$ & PM_1) concentration was monitored in indoor as well as the outdoor environment of the complex. The hourly average concentrations for PM_{10}, $PM_{2.5}$ & PM_1 was found in the range of 137-141, 70-86 and 44-67 µg/m3, respectively. Indoor-Outdoor ratio of PM concentrations for all microenvironments was found greater than 1. Fractional analysis of various PM sizes has describe the contribution of different PMs from various indoor and outdoor sources. Results of the present study would find implication in exposure analysis and help the regulating authority to develop the policy framework on indoor air quality.

Keywords: ***IAQ, Particulate Pollution, Air Quality***

INTRODUCTION

Air quality of the indoor environment directly influence the human health, people spend almost 80 to 90% of their time in different indoor environments which highlights the importance of the assessment of indoor air quality (IAQ). Indoor pollutant sources, building materials, ventilation and designs of the urban building affect the air quality inside its microenvironments [1]. Poor Indoor Air Quality (IAQ) inside homes, offices, schools and colleges has also been linked to increases in sick building syndrome along with losses in productivity and performances in schools /colleges and offices [2]. Particulate matter (PM) concentration, being the criteria air pollutants, is one of the indicator for indoor as well as outdoor air quality. Various physical and chemical characteristics of PM are potential contributors to adverse health effects. Large number of epidemiologic studies addressed the adverse health effects of both short-term and long-term exposure to PM concentration [3, 4].

Air quality in libraries, lecture halls, laboratories and other microenvironments of schools and colleges where the students spend most of the time of the day, is very important for healthy learning environment and worthy academic performance [5].

Therefore, the aim of the present study is to assess the indoor Air Quality (IAQ) as indoor particulate matter concentration in order to find out the spatial variations of particulate pollution in Lecture hall complex of Indian Institute of Technology Roorkee.

METHODOLOGY

Site description:

Indian Institute of Technology (IIT) Roorkee is one of the premium technical institute of India, Established in 1847 at Roorkee city of Uttarakhand (29° 51′ 52″ N, 77° 53′ 47″ E). New Lecture hall complex (NLHC) of IIT Roorkee was selected as study site for this study. NLHC is a three story building, have 18 large lecture halls of occupancy of around 150-200 at each hall, 15 tutorial class rooms and other facility rooms. All the lecture halls are equipped with air conditions, wall fans and selling fans but due the frequent window opening the ventilation of the halls are categorized as mixed kind of ventilation (natural and mechanical both).

Monitoring:

PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ measurements were made for eight hours on five consecutive days in lecture halls at a sampling rate of 5 min using environmental dust monitors

(GRIMM make, Model 1.109). Continuous Monitoring was performed from 10AM to 6PM in lecture halls at each floor of the NLHC except top floor due to the different design and occupancy of the top floor classrooms.

The sampling procedure involved conducting three to five indoor measurements and the instrument was located at the height of 1.3m above the floor and at least 1m away from the wall. Inlet head was positioned as close as possible to the breathing zone for the occupants. Outdoor monitoring was also performed continuously for 24 hours, to develop the Indoor-Outdoor relationship during the period of occupancy.

This 31-channel dust monitors work on the principle of light scattering by drawing air at a sample flow rate of 1.2 L/min and detects the particle in the size range of 0.3–25µm then convert to mass using well-established conversion equations [6].

Results and Discussion

Indoor Particulates Concentrations: The hourly average concentrations for PM_{10} (141±26 µg/m^3) was found highest in lecture hall at 1st floor whereas $PM_{2.5}$, and $PM_{1.0}$ concentrations (86±10 and 67±9 µg/m^3, respectively) were highest at second floor. The 8-h average outdoor PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ concentrations were 96.7± 3.7, 56.9± 2.8, and 40.1±2.6 µg/m^3, respectively. Spatial variation of particulate pollution at different floor of the NLHC can be relate to the variation in occupancy and ventilation. Table 1 shows the 8-hourly average values of different PM types in lecture halls at floor and the variation of concentration for PM shown in figure 1.

TABLE 1: Concentration of different PM types in studied indoor environments

PM Concentration in indoor environment(µg/m3)												
	PM10				PM2.5				PM1			
Site	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Ground Fl	139.2	169.4	87.1	25.4	82.7	108.1	74.4	13.5	61.5	88.9	51.2	10.8
1st Floor	141.1	186.9	97.6	25.7	70.3	101.6	69.5	11.3	44.1	84.2	51.6	12.0
2nd Floor	137.2	207.8	89.8	35.0	86.3	84.6	58.6	10.4	66.9	57.9	34.6	9.1
Outdoor	96.7	101.7	92.4	3.5	56.7	60.6	53.8	2.7	39.8	43.6	37.3	2.6

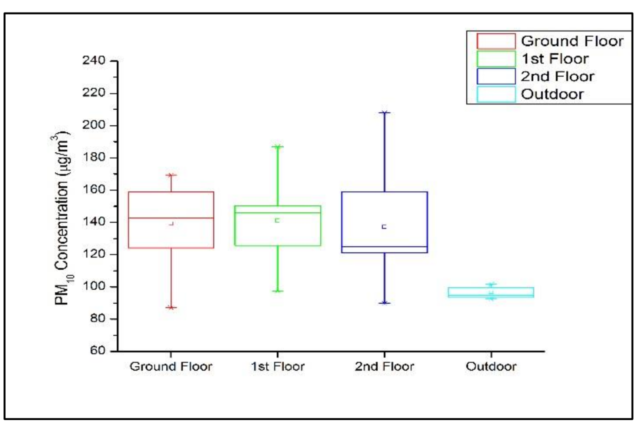

FIGURE 1a. Concentration variation for PM_{10}

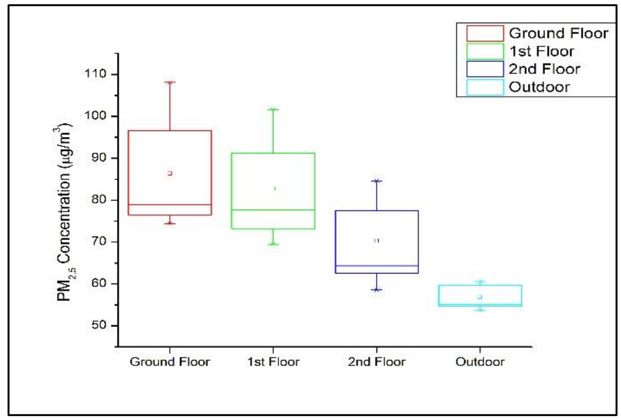

FIGURE 1b. Concentration variation for $PM_{2.5}$

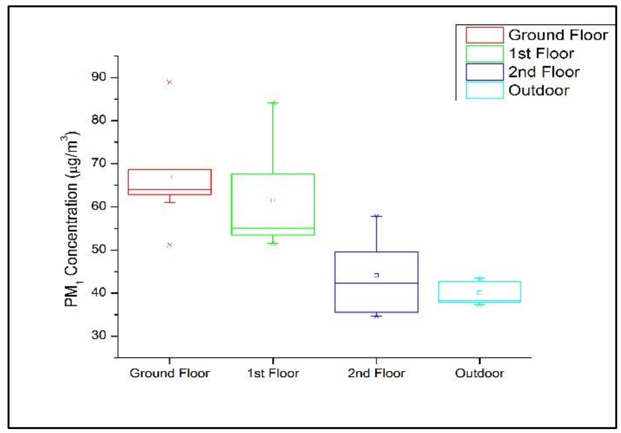

FIGURE 1c. Concentration variation for PM_1

I/O relationship:

Indoor-Outdoor ratio of PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ was calculated for all the selected lecture halls to understand the contribution from various indoor activities and the infiltration of particles from the outdoor environment. The hourly average outdoor concentrations of various PM fractions, was used to calculate the I /O ratio for different PM types in the studied indoor environments during working hours (Fig. 2). I/O ratio for various PM types was found in the range of 1.43- 1.54 at Ground floor, 1.10-1.44 at 1st floor and 1.41-1.67 2nd floor. I/O ratio shows the decline trend from Ground floor to first floor. Highest I/O ratio for $PM_{2.5}$ and $PM_{1.0}$ was found at 2nd floor whereas it was for PM_{10} at Ground floor.

These observations suggest that the outdoor infiltration and the indoor activities are responsible for the higher I /O in indoor environments. In line with the previous findings [7,8], the key parameters, which are supposed to regulator the I /O ratio of PM in our study, are the air exchange rate between the indoor and the outdoor air and the particle resuspension. The results of several other studies also exhibited the varying range of I /O ratio as 0.5 to 2.0 in different indoor environments in the absence and presence of indoor sources, respectively [9,10].

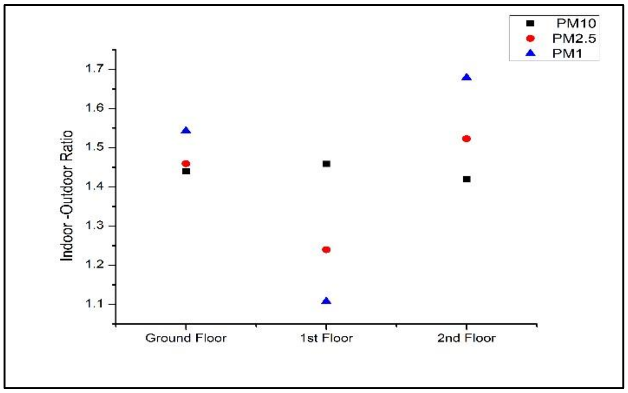

FIGURE 2. I/O ratio of PM10, PM2.5, and PM1.0

Proportion of PM fractions:

Fractional analysis of various PM sizes has also been carried out to understand the contribution of different PMs from various indoor and outdoor sources. Figure 3 shows the proportion of different PM fractions in all the selected indoor environments and during outdoor measurements. Together, the PM2.5 (17 %) and PM1.0 (41 %) contributes ~58 % of the total PM10 concentration in outdoor ambient air, leaving only 41 % for PM2.5–10.

By looking at the indoor concentrations separately at different floor, PM fraction at Ground floor's lecture hall shows nearly identical proportions as were outdoors even though having mixed ventilation. The sum of PM2.5 and PM1.0 contributed ~59 % of total PM as opposed to ~58 %in outdoors, this can be expected given the frequent opening of doors/windows, allowing free movement of outdoor air. Whereas the fractional variation PM Concentration is of different order for 1st and 2nd floor's lecture hall.

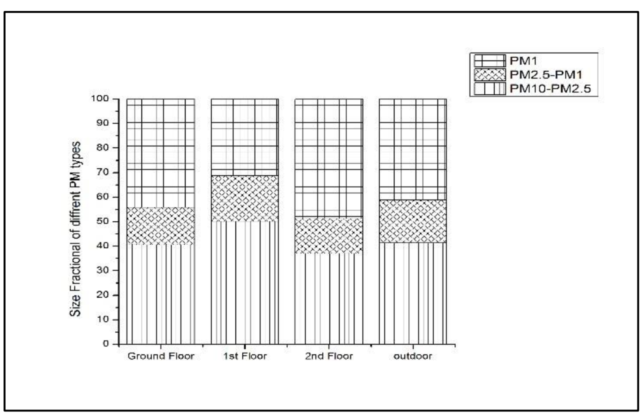

FIGURE 3. Proportion of PM concentrations in various size ranges

CONCLUSION

Higher concentration of coarse particles was found at first floor of NLHC whereas the concentration of fine particles was higher at 2nd and 3rd floor. Which shows the spatial variation of indoor particle concentration in lecture hall complex. I/O ratio of different PM types also followed the spatial variation which depicts the variation of IAQ in lecture hall at different floor of the complex. Ventilation of the lecture hall also affect the I/O ratio of PM concentration. Overall the fine fraction particles was found higher compare to coarse fraction.

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